

Hertzsprung gap Coronae (NAG5-3327: ASCA Guest Investigator Program)

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FINAL REPORT

SUMMARY.— ASCA Program: “HERTZSPRUNG GAP CORONAE”—Objective was a deep (40 ks) SIS/GIS pointing on the bright stellar X-ray source 31 Comae (G0 III) to record the 1–10 keV spectrum and obtain a lightcurve over the ~ 1 day duration of the observation.

The following is the final report on an *ASCA* program to record the X-ray spectrum and lightcurve of the bright X-ray source 31 Comae, an G0 giant passing through the Hertzsprung gap. The 40 ks pointing was conducted early in cycle 4. The source was detected at a level of 0.3 cts s^{-1} . The SIS and GIS light curves were very stable during the period of observation, indicating a lack of flare activity. The source was relatively hard, indicating a mean coronal temperature in excess of $\sim 10^7 \text{ K}$.

The X-ray coronae of the fast-rotating Hertzsprung-gap giants (F0–G1 III) like 31 Comae are among the hottest known ($\log T > 7.3 \text{ K}$); reminiscent of flaring gas in solar active regions, or on RS CVn binaries and dMe stars. Yet, these giants as a class are not noted for transient UV or X-ray outbursts; and indeed, they are *X-ray-deficient* with respect to coronal proxies like Si IV $\lambda 1400$. The paradox—flare-temperature plasma, in the face of X-ray deficiency and lack of overt flaring—bears on the nature of coronal heating at the crucial evolutionary juncture where shallow convective envelopes first emerge; the key transition between hot-star and cool-star X-ray activity.

We modeled the *ASCA*/SIS0 spectrum using a multi-spectral procedure we had developed previously for HST, EUVE, and ROSAT data. We constructed a differential volume emission measure distribution, based primarily on the high-quality EUVE SW and MW spectra, and introduced the other diagnostics as subsidiary constraints. *ASCA* provided the crucial strong constraint on the high-temperature extension of the emission-measure

distribution. best-fit *DVEM* curve: the upper temperature extension ($\log T > 7.3$ K) was established by the ASCA/SIS0 spectrum (above 1.5 keV).

2T XSPEC simulations obtained a good fit for solar abundances, except for Mg: it was raised to $1.7\odot$ to “fill in” a flux deficit near 1.3 keV. A similar effect has been noted in other ASCA coronal spectra: it more likely is due to problems with the high- T emissivities, than to a genuine compositional anomaly.

The puzzle of the Hertzsprung gap coronae is why they are very hot despite the high ratio of C IV-to-X-ray emission which—in the context of solar loop scaling models—implies a rather cool corona. If the solar models are to hold (i.e., imposing a physical connectedness between the coronal and TZ emissions) the magnetic loops on the shallow convection zone giants must have fat footpoints and highly-constricted apices. On the other hand, these stars simply might support a dual population of coronal structures that is very unlike the demographics of the solar case. The high- T emission might arise in highly extended hot loops (whose large lengths would inhibit short-term variability); whereas most of the TZ flux might arise in more compact structures (owing to pressure scale height considerations) which have relatively cool T_{max} ’s (say, $< 10^6$ K).

Based on *ASCA* and *EUVE* low-res spectra and *HSTGHRS* medium-res spectra of 31 Com and related giants, we (myself and coauthor Alex Brown) developed a theory to explain the presence of long, hot loops on the Hertzsprung gap stars. Our hypothesis involves a remnant dipolar “magnetosphere” left over from the main sequence phase (when the star was an A or B-type dwarf), which is energized by flows associated with the shallow surface convection zone, but not yet disrupted by it. Later, the deepening convection zone shreds the fossil dipolar field and replaces it with solar-like “dynamo”-generated surface activity. When at full strength, the large-scale dipolar field inhibits mass loss by an ionized coronal wind. When the magnetosphere is removed, however, the coronal wind becomes unconstrained, and the associated rapid loss of angular momentum causes the star to spindown on a short timescale. The slowing of rotation debilitates the spin-catalyzed dynamo, and the giants enter a low-activity phase of their coronal evolution. Our model nicely explains several of the curious features of the post-main sequence development of coronae among the moderate-mass giants, but many details remain to be worked out.

A preliminary version of the work was presented as a poster paper at the 1996 HEAD meeting in San Diego. A detailed study, including also a cycle 5 *ASCA* observation of the related star HR 9024 (G1 III), was presented as a poster at the 1997 HEAD meeting in Estes Park. A formal publication is in preparation, pending additional modeling of the SIS and GIS data sets.